STABILITY RISK ASSESSMENT

for

BRYN AGGREGATES LTD
MATERIALS RECYCLING FACILITY
MATERIALS STORAGE YARD EXTENSION
GELLIARGWELLT FARM, GELLIGAER ROAD, GELLIGAER, CAERPHILLY

Prepared for:-

Date: July 2023

Submitted by:-

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1 INTRODUCTION

1.1 General

JPCE Limited are commissioned by Bryn Recycling Ltd to prepare a stability risk assessment (SRA) in support of the Waste Recovery Plan (WRP) for the deposit of waste material on land for the extension to the materials storage yard at the existing Material Recycling Facility, Gelligaer. The location of the site is shown on drawing no. BRL-MRFYD-2023-003.

Details of the environmental setting of Bryn Quarry, the geology, the hydrogeology, the design of the landfill site and the history of operations at the site are described in the WRP and Hydrogeological Risk Assessment and should be referenced with this report.

1.2 Conceptual stability site model

The materials storage year will be constructed in an area of historic opencast coal mining. The opencast excavated the Mynyddislwyn seam within the Carboniferous Upper Pennant Measures. We are informed by the client that this area was backfilled with compacted clay rich soils. There are three major components of the conceptual stability site model which are sandstone bedrock, the basal subgrade and the imported waste soils.

Each of the major components of the conceptual stability site model are described in the stability risk assessment and are the subject of a process of risk screening and any necessary risk assessment.

1.2.1 *Basal subgrade model*

The base of the imported soils will be the existing clay rich soils overlying the sandstone bedrock. The existing topography of the clay-rich soils is a gently sloping field with the falls tending in a south-westerly direction, the general topography is shown on drawing no BRL-MRFYD-2021-001B.

1.2.2 *Waste mass model*

It is proposed that the yard extension landform will accept strictly inert wastes in accordance with the WRP.

1.2.3 *Capping system model*

The capping layer comprises 1m thick restoration soils created using suitable inert wastes as described in the WRP. The slopes of the restoration profile and cultivation of the soils will encourage efficient surface water runoff. The waste mass is bounded by the quarry face on the north-eastern, south-eastern and south-western sides. The steepest face is the north-western face and is approximately 11m high with gradients in the range of 1v:3h, with localised areas of approximately 1v:2.5h. The restoration scheme is shown on drawing no. BRL-MRFYD-2023-011revA

2 STABILITY RISK ASSESSMENT

2.1 Risk screening

2.1.1 *Basal and side slope subgrade screening*

As the surface of the basal subgrade comprises the existing well compacted, clay rich soils overlying the sandstone bedrock it is considered unnecessary to undertake slope stability analyses of the basal subgrade. The ground profile has slopes of circa 1:5 (v:h) and is therefore less steep than the proposed new slope.

2.1.2 *Basal and side slope lining system screening*

No basal and side slope lining system is proposed.

2.1.3 *Waste mass screening*

As no temporary slopes in the imported soils will be constructed steeper than the gradient of the steepest and longest capping system slope it is not considered necessary to separately analyse quantitively the stability of the waste mass.

2.1.4 *Capping system screening*

As the slope of the capping system will be constructed at a gradient of up to 1v:3h it is considered necessary to analyse quantitively the stability of the capping system.

2.2 Data summary

The data used in the stability analyses and the data sources are presented in Table SRA1.

2.3 Justification for modelling approach and software

The stability analyses have been carried out at the highest and steepest slope for final landform. The steepest and longest slope of the waste mass is shown on Section A'-A', on drawing the BAL-MRFYD-2023-015.

Although it is unlikely that drained (long term) conditions will be achieved in full in the imported soils they analysed on the conservative assumption that drained (long term) conditions have been fully achieved.

The stability analyses undertaken for the purposes of this report are carried out using the two-dimensional limit equilibrium programme GEO5. The slopes are analysed using the Bishop method.

2.4 Justification of geotechnical parameters selected for analyses

2.4.1 *Parameters selected for basal subgrade analyses, basal liner, side slopes subgrade and side slope liner analyses*

As no basal subgrade analyses, basal liner, side slopes subgrade, side slope liner analyses have been carried out no geotechnical parameters are presented.

2.4.2 *Parameters selected for waste analyses and capping system analyses*

The data used for the analyses of the basal and side slope subgrade and the waste mass and the capping system together with their sources are presented in Table 1.

Table 1 Geotechnical parameters used in the analyses

Material	Geotechnical parameters and values	
	Short term (undrained)	Long term (drained)
Imported soils [1]	c_u = 75kPA ϕ_u = 0° Bulk unit weight = 19kN/m³	c' = 0kPA ϕ' = 30° Bulk unit weight = 19kN/m³
Basal clay-rich soils[1]	N/A	c' = 150kPA ϕ' = 0° Bulk unit weight = 21kN/m³
Sandstone bedrock	N/A	c' = 300kPA ϕ' = 0° Bulk unit weight = 20kN/m³

[1] Conservative values based on JPCE professional experience.

2.5 Groundwater levels

To reflect rainfall infiltration into the proposed ground strata of imported soils overlying the existing clay rich opencast backfill, the groundwater table has been modelled at the interface between the imported and existing soils. There are no springs on the slopes indicating that the natural groundwater table is either below the ground elevation of the opencast back or confined by it.

2.6 Design loadings

An additional variable load of 100kN/m^2 has been added to the model to account for the vehicle loads and materials stored on the yard extension.

2.7 Selection of Appropriate Factors of Safety

It is currently recommended that earthworks design is undertaken in accordance with BS EN 1997-1:2004 using partial factors applied to the loads and material properties. Additionally, stability analysis has also been undertaken using the traditional 'global factor of safety approach', whereby the target Factor of Safety (FoS) of 1.3 is required.

The effects of a waste mass failure will be confined to the imported soils and there will be no effect on structures outside the landfill. It is considered that a factor of safety of 1.3 is appropriate for both the long term and short term conditions.

2.8 Analyses

2.8.1 *Basal and subgrade analyses*

No analysis has been conducted on a basal and side slope subgrade.

2.8.2 *Basal and side slope liner analyses*

No basal and side slope lining system is proposed.

2.8.3 *Waste mass and capping analyses*

The results of the analyses are presented in Table 2 and at Appendix SRA1.

Table 2 Results of the slope stability analyses

Model	**Factor of safety**	**Slope stability criteria satisfied**
Traditional Factor of Safety approach		
Section A-A' – short term	1.92	Yes
Section A-A' – long term	1.77	Yes
Model	**Utilisation**	**Slope stability criteria satisfied**
EC7 design approach 1 – combination 1		
Section A-A' – short term	72.9%	Yes
Section A-A' – long term	60.8%	Yes

2.9 Assessment

The slope stability analyses undertaken confirms that the proposed landform achieves the required criteria for slope stability for both the BS EN 1997-1:2004 and traditional global factor of safety approach.

3 MONITORING

3.1 The risk based monitoring scheme

The results of the stability risk assessment show satisfactory factors of safety at all stages of the site development. It is considered appropriate to undertake an annual topographical survey to identify areas of settlement or instability and a weekly visual inspection of the exposed subgrade and imported soils for signs of settlement and instability during the stages of construction. Following completion a visual inspection for signs of settlement or instability will be undertaken during topographical survey visits.

Should an area of concern be identified from the weekly visual inspections or during subsequent inspections Natural Resources Wales will be notified as soon as possible. Proposals to remediate instability will be included in the notification to NRW.

Any deviation from the modelled assumptions (landform geometry, drainage design) used in this stability analysis shall be reported back to the author and the models re-run to assess the impact on the overall stability of the proposed landform.

DRAWINGS

Drawing No.	Title
Drawing No. BRL-MRFYD-2021-001revC	Existing Plan
Drawing No. BRL-MRFYD-2023-003	Site Location Plan
Drawing No. BRL-MRFYD-2023-011revA	Proposed Plan
Drawing No. BAL-MRFYD-2023-015	Typical Cross Section Through Fill Area

APPENDIX SRA1

RESULTS OF THE STABILITY ANALYSES

Slope stability analysis

Input data (Construction stage 1)

Project

Task : Yard extension stability assessment
Part : Long term conditions - traditional FoS
Description : Section A-A'
Customer : Bryn Aggregates Ltd
Author : JPCE Ltd
Date : 07/10/2023

Settings

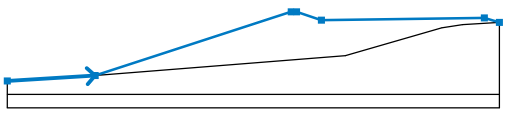
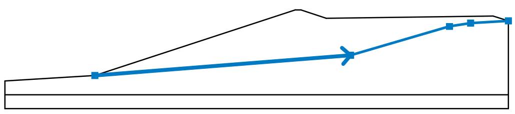
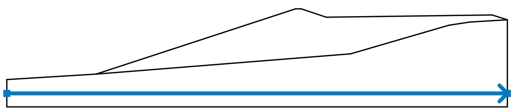
Standard - safety factors

Stability analysis

Verification methodology : Safety factors (ASD)
Earthquake analysis : Standard

Safety factors			
Permanent design situation			
Safety factor :	SF_s =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	32.72	2.02	105.67	25.82
		107.77	25.82	116.94	22.72	177.69	23.54
		183.30	21.85				
2		32.72	2.02	125.88	9.40	161.86	19.80
		169.57	21.03	183.30	21.85		
3		0.00	-5.00	183.30	-5.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Imported soils		30.00	0.00	19.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	Imported soils		19.00		

Soil parameters - total stress state

No.	Name	Pattern	c_u [kPa]	γ [kN/m^3]
1	In-situ clay soils		150.00	21.00
2	Sandstone bedrock		300.00	20.00

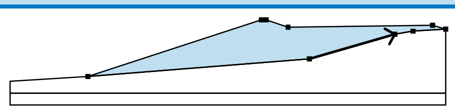
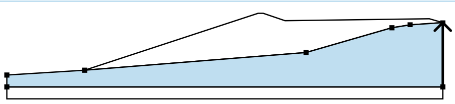
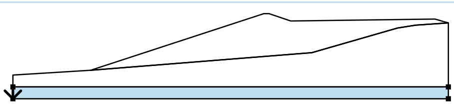
Soil parameters

In-situ clay soils
Unit weight : γ = 21.00 kN/m^3
Stress-state : total
Shear strength : Mohr-Coulomb
Cohesion of soil : c_u = 150.00 kPa

Imported soils
Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Shear strength : Mohr-Coulomb
Angle of internal friction : φ_{ef} = 30.00 °
Cohesion of soil : c_{ef} = 0.00 kPa
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Sandstone bedrock
Unit weight : γ = 20.00 kN/m^3
Stress-state : total
Shear strength : Mohr-Coulomb
Cohesion of soil : c_u = 300.00 kPa

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		125.88	9.40	161.86	19.80	Imported soils
		169.57	21.03	183.30	21.85	
		177.69	23.54	116.94	22.72	
		107.77	25.82	105.67	25.82	
		32.72	2.02			
2		183.30	-5.00	183.30	21.85	In-situ clay soils
		169.57	21.03	161.86	19.80	
		125.88	9.40	32.72	2.02	
		0.00	0.00	0.00	-5.00	
3		0.00	-5.00	0.00	-10.00	Sandstone bedrock
		183.30	-10.00	183.30	-5.00	

Surcharge

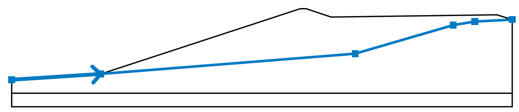
No.	Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F, x	q_2, z	unit
1	strip	permanent	on terrain	x = 117.00	l = 60.00		0.00	100.00		kN/m^2

Surcharges

No.	Name
1	Working loads

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-0.14	32.63	1.97	125.80	9.40
		161.68	19.84	169.58	21.11	183.30	21.84

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-26.73	[m]	Angles :	α_1 =	17.51	[°]
	z =	328.38	[m]		α_2 =	18.63	[°]
Radius :	R =	328.72	[m]				
Slip surface after grid search.							

Total weight of soil above the slip surface: 1.11 kN/m

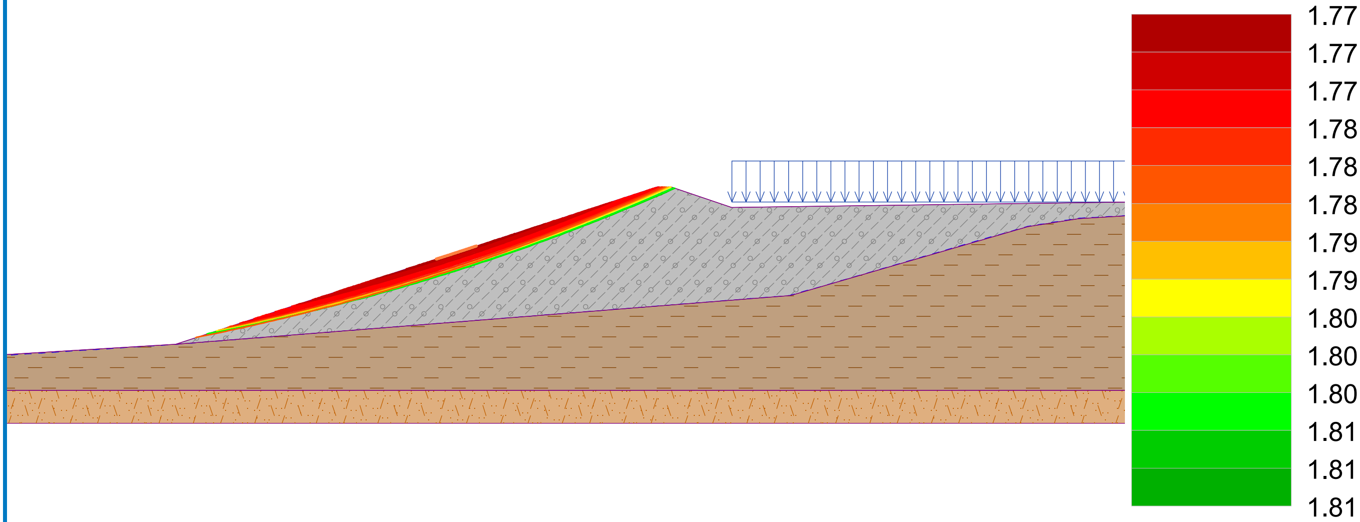
Slope stability verification (Bishop)

Sum of active forces : F_a = 0.35 kN/m
Sum of passive forces : F_p = 0.61 kN/m

Sliding moment : M_a = 113.48 kNm/m
Resisting moment : M_p = 200.52 kNm/m
Factor of safety = 1.77 > 1.50

Slope stability ACCEPTABLE

Name : Analysis **Stage - analysis : 1 - 1**



Slope stability analysis

Input data (Construction stage 1)

Project

Task : Yard extension stability assessment
Part : Long term conditions - DA1
Description : Section A-A'
Customer : Bryn Aggregates Ltd
Author : JPCE Ltd
Date : 07/10/2023

Settings

Standard - EN 1997 - DA2 (2)

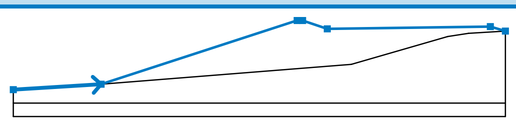
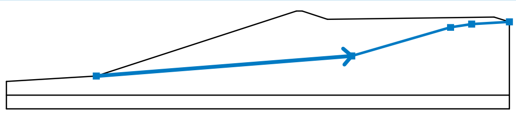
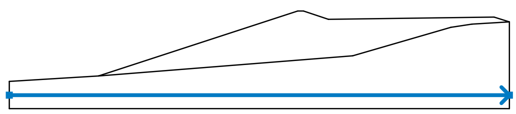
Stability analysis

Verification methodology : according to EN 1997
Earthquake analysis : Standard
Design approach : 1 - reduction of actions and soil parameters

Partial factors on actions (A)									
Permanent design situation									
		Combination 1				Combination 2			
		Unfavourable		Favourable		Unfavourable		Favourable	
Permanent actions :	γ_G =	1.35	[–]	1.00	[–]	1.00	[–]	1.00	[–]
Variable actions :	γ_Q =	1.50	[–]	0.00	[–]	1.30	[–]	0.00	[–]
Water load :	γ_w =	1.35	[–]			1.00	[–]		

Partial factors for soil parameters (M)					
Permanent design situation					
		Combination 1		Combination 2	
Partial factor on internal friction :	γ_ϕ =	1.00	[–]	1.25	[–]
Partial factor on effective cohesion :	γ_c =	1.00	[–]	1.25	[–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00	[–]	1.40	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	32.72	2.02	105.67	25.82
		107.77	25.82	116.94	22.72	177.69	23.54
		183.30	21.85				
2		32.72	2.02	125.88	9.40	161.86	19.80
		169.57	21.03	183.30	21.85		
3		0.00	-5.00	183.30	-5.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	Imported mixed soils		30.00	0.00	19.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Imported mixed soils		20.00		

Soil parameters - total stress state

No.	Name	Pattern	c_u [kPa]	γ [kN/m^3]
1	In-situ clay soils		150.00	21.00
2	Sandstone bedrock		300.00	20.00

Soil parameters

In-situ clay soils

Unit weight :	γ = 21.00 kN/m^3
Stress-state :	total
Shear strength :	Mohr-Coulomb
Cohesion of soil :	c_u = 150.00 kPa

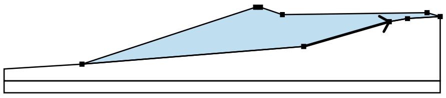
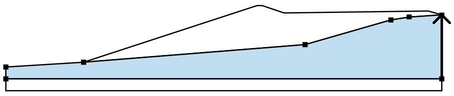
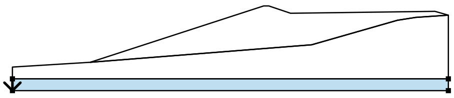
Imported mixed soils

Unit weight :	γ = 19.00 kN/m^3
Stress-state :	effective
Shear strength :	Mohr-Coulomb
Angle of internal friction :	φ_{ef} = 30.00 °
Cohesion of soil :	c_{ef} = 0.00 kPa
Saturated unit weight :	γ_{sat} = 20.00 kN/m^3

Sandstone bedrock

Unit weight :	γ = 20.00 kN/m^3
Stress-state :	total
Shear strength :	Mohr-Coulomb
Cohesion of soil :	c_u = 300.00 kPa

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		125.88	9.40	161.86	19.80	Imported mixed soils
		169.57	21.03	183.30	21.85	
		177.69	23.54	116.94	22.72	
		107.77	25.82	105.67	25.82	
		32.72	2.02			
2		183.30	-5.00	183.30	21.85	In-situ clay soils
		169.57	21.03	161.86	19.80	
		125.88	9.40	32.72	2.02	
		0.00	0.00	0.00	-5.00	
3		0.00	-5.00	0.00	-10.00	Sandstone bedrock
		183.30	-10.00	183.30	-5.00	

Surcharge

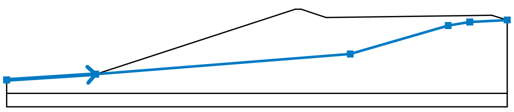
No.	Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F, x	q_2, z	unit
1	strip	permanent	on terrain	x = 117.00	l = 60.00		0.00	100.00		kN/m2

Surcharges

No.	Name
1	Working loads

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-0.14	32.63	1.97	125.80	9.40
		161.68	19.84	169.58	21.11	183.30	21.84

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters								
Center :	x =	74.89	[m]	Angles :	α_1 =	-33.26	[°]
	z =	55.56	[m]		α_2 =	57.28	[°]
Radius :	R =	60.53	[m]				
Slip surface after grid search.							

Total weight of soil above the slip surface: 26693.50 kN/m

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 7992.09 kN/m
Sum of passive forces : F_p = 13141.14 kN/m

Sliding moment : M_a = 467776.79 kNm/m
Resisting moment : M_p = 769150.75 kNm/m
Utilization : 60.8 %

Slope stability ACCEPTABLE

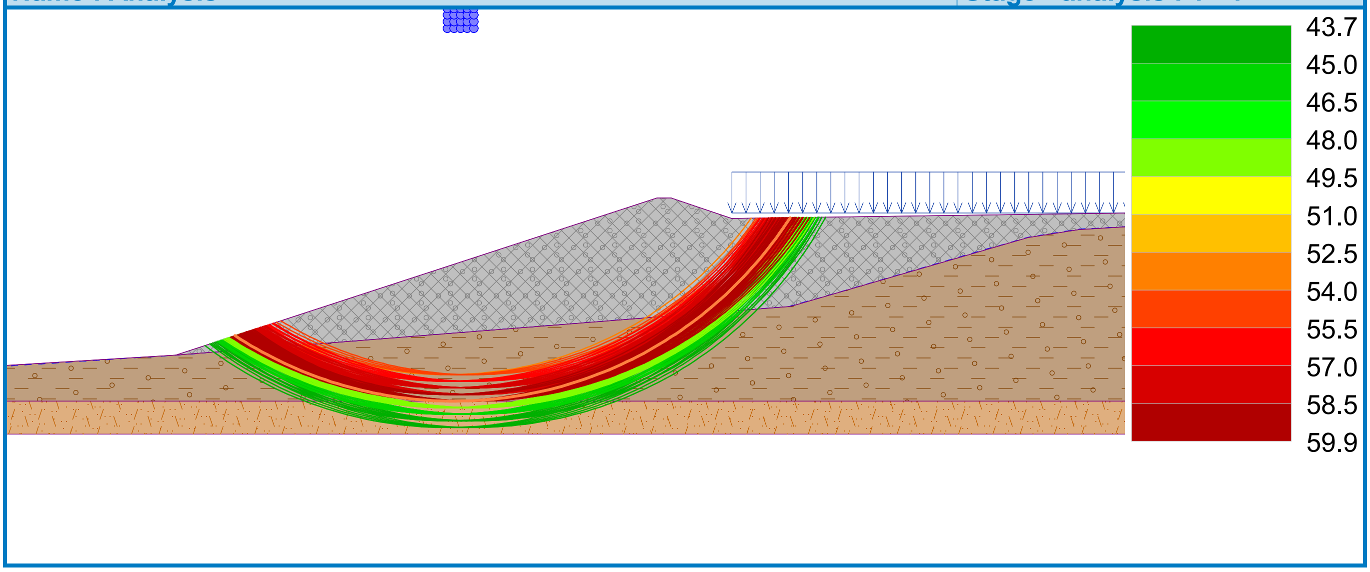
Combination 2

Sum of active forces : F_a = 5588.41 kN/m
Sum of passive forces : F_p = 9332.62 kN/m

Sliding moment : M_a = 338266.23 kNm/m
Resisting moment : M_p = 564903.78 kNm/m
Utilization : 59.9 %

Slope stability ACCEPTABLE

Name : Analysis	Stage - analysis : 1 - 1



Slope stability analysis

Input data (Construction stage 1)

Project

Task : Yard extension stability assessment
Part : Short term conditions - traditional FoS
Description : Section A-A'
Customer : Bryn Aggregates Ltd
Author : JPCE Ltd
Date : 07/10/2023

Settings

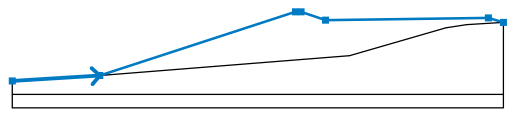
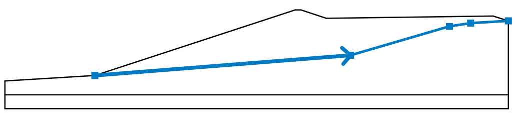
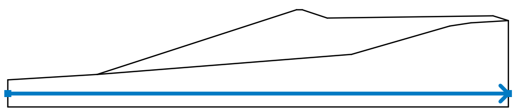
Standard - safety factors

Stability analysis

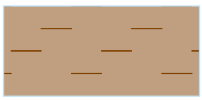
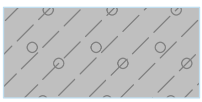
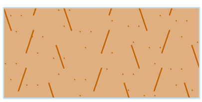
Verification methodology : Safety factors (ASD)
Earthquake analysis : Standard

Safety factors			
Permanent design situation			
Safety factor :	SF_s =	1.50	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		0.00	0.00	32.72	2.02	105.67	25.82
		107.77	25.82	116.94	22.72	177.69	23.54
		183.30	21.85				
2		32.72	2.02	125.88	9.40	161.86	19.80
		169.57	21.03	183.30	21.85		
3		0.00	-5.00	183.30	-5.00		

Soil parameters - total stress state

No.	Name	Pattern	c_u [kPa]	γ [kN/m^3]
1	In-situ clay soils		150.00	21.00
2	Imported soils		75.00	19.00
3	Sandstone bedrock		300.00	20.00

Soil parameters

In-situ clay soils

Unit weight :	γ = 21.00 kN/m^3
Stress-state :	total
Shear strength :	Mohr-Coulomb
Cohesion of soil :	c_u = 150.00 kPa

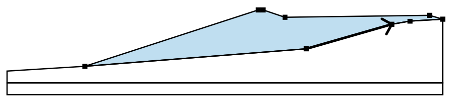
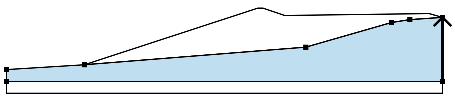
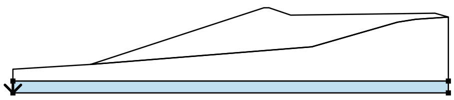
Imported soils

Unit weight :	γ = 19.00 kN/m^3
Stress-state :	total
Shear strength :	Mohr-Coulomb
Cohesion of soil :	c_u = 75.00 kPa

Sandstone bedrock

Unit weight :	γ = 20.00 kN/m^3
Stress-state :	total
Shear strength :	Mohr-Coulomb
Cohesion of soil :	c_u = 300.00 kPa

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		125.88	9.40	161.86	19.80	Imported soils
		169.57	21.03	183.30	21.85	
		177.69	23.54	116.94	22.72	
		107.77	25.82	105.67	25.82	
		32.72	2.02			
2		183.30	-5.00	183.30	21.85	In-situ clay soils
		169.57	21.03	161.86	19.80	
		125.88	9.40	32.72	2.02	
		0.00	0.00	0.00	-5.00	
3		0.00	-5.00	0.00	-10.00	Sandstone bedrock
		183.30	-10.00	183.30	-5.00	

Surcharge

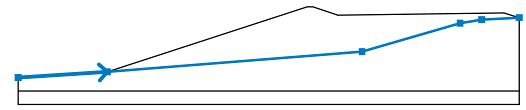
No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude q, q_1, f, F, x	Magnitude q_2, z	Magnitude unit
1	strip	permanent	on terrain	x = 117.00	l = 60.00		0.00	100.00		kN/m^2

Surcharges

No.	Name
1	Working loads

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-0.14	32.63	1.97	125.80	9.40
		161.68	19.84	169.58	21.11	183.30	21.84

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	74.98	[m]	Angles :	α_1 =	-13.67	[°]
	z =	101.87	[m]		α_2 =	34.83	[°]
Radius :	R =	96.21	[m]				
The slip surface after optimization.							

Total weight of soil above the slip surface: 13716.73 kN/m

Slope stability verification (Bishop)

Sum of active forces : F_a = 3180.70 kN/m

Sum of passive forces : F_p = 6108.01 kN/m

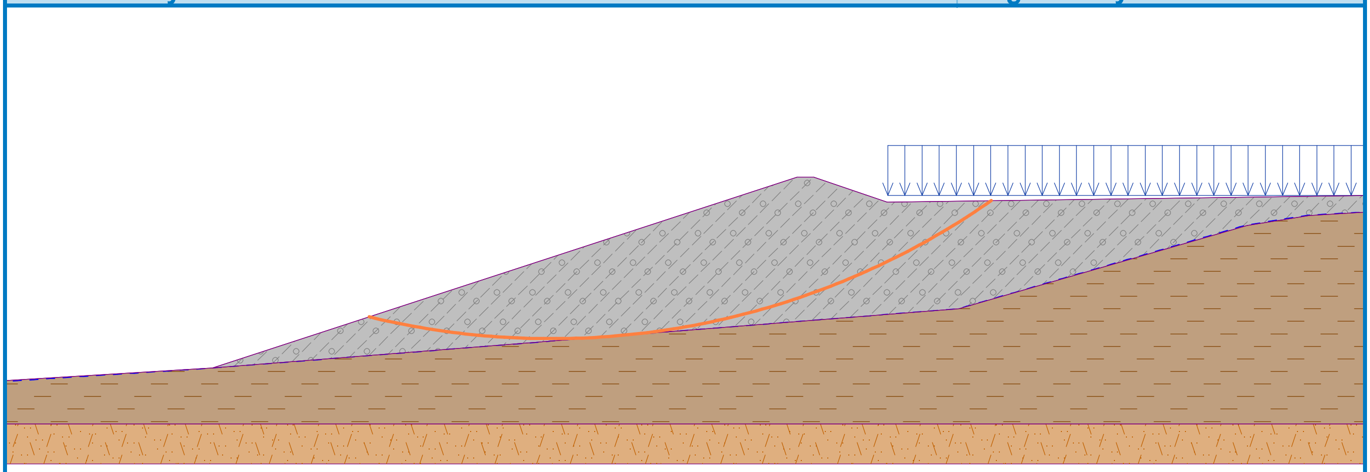
Sliding moment : M_a = 306015.08 kNm/m

Resisting moment : M_p = 587651.79 kNm/m

Factor of safety = 1.92 > 1.50

Slope stability ACCEPTABLE

Name : Analysis	Stage - analysis : 1 - 1



Slope stability analysis

Input data (Construction stage 1)

Project

Task :	Yard extension stability assessment
Part :	Short term conditions - DA1
Description :	Section A-A'
Customer :	Bryn Aggregates Ltd
Author :	JPCE Ltd
Date :	07/10/2023

Settings

Standard - safety factors (2)

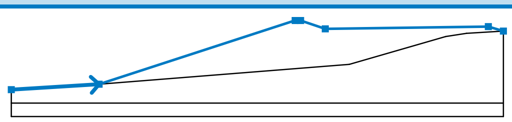
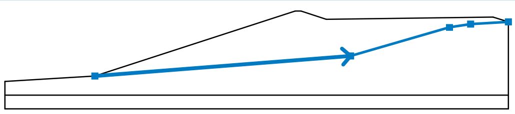
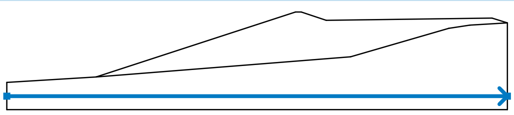
Stability analysis

Verification methodology :	according to EN 1997
Earthquake analysis :	Standard
Design approach :	1 - reduction of actions and soil parameters

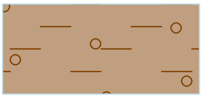
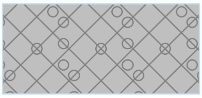
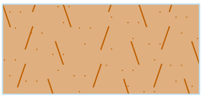
Partial factors on actions (A)					
Permanent design situation					
		Combination 1		Combination 2	
		Unfavourable	Favourable	Unfavourable	Favourable
Permanent actions :	γ_G =	1.35 [–]	1.00 [–]	1.00 [–]	1.00 [–]
Variable actions :	γ_Q =	1.50 [–]	0.00 [–]	1.30 [–]	0.00 [–]
Water load :	γ_w =	1.35 [–]		1.00 [–]	

Partial factors for soil parameters (M)			
Permanent design situation			
		Combination 1	Combination 2
Partial factor on internal friction :	γ_ϕ =	1.00 [–]	1.25 [–]
Partial factor on effective cohesion :	γ_c =	1.00 [–]	1.25 [–]
Partial factor on undrained shear strength :	γ_{cu} =	1.00 [–]	1.40 [–]

Interface

No.	Interface location	Coordinates of interface points [m] x	z	x	z	x	z
1		0.00	0.00	32.72	2.02	105.67	25.82
		107.77	25.82	116.94	22.72	177.69	23.54
		183.30	21.85				
2		32.72	2.02	125.88	9.40	161.86	19.80
		169.57	21.03	183.30	21.85		
3		0.00	-5.00	183.30	-5.00		

Soil parameters - total stress state

No.	Name	Pattern	c_u [kPa]	γ [kN/m^3]
1	In-situ clay soils		150.00	21.00
2	Imported mixed soils		75.00	19.00
3	Sandstone bedrock		300.00	20.00

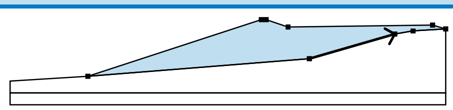
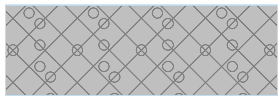
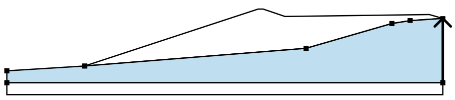
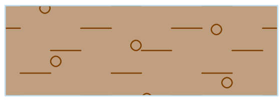
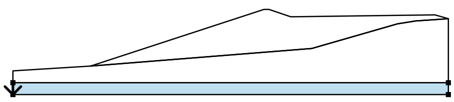
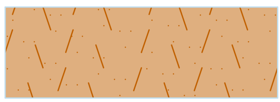
Soil parameters

In-situ clay soils
Unit weight : γ = 21.00 kN/m^3
Stress-state : total
Shear strength : Mohr-Coulomb
Cohesion of soil : c_u = 150.00 kPa

Imported mixed soils
Unit weight : γ = 19.00 kN/m^3
Stress-state : total
Shear strength : Mohr-Coulomb
Cohesion of soil : c_u = 75.00 kPa

Sandstone bedrock
Unit weight : γ = 20.00 kN/m^3
Stress-state : total
Shear strength : Mohr-Coulomb
Cohesion of soil : c_u = 300.00 kPa

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m] x	z	x	z	Assigned soil
1		125.88	9.40	161.86	19.80	Imported mixed soils
		169.57	21.03	183.30	21.85	
		177.69	23.54	116.94	22.72	
		107.77	25.82	105.67	25.82	
		32.72	2.02			
2		183.30	-5.00	183.30	21.85	In-situ clay soils
		169.57	21.03	161.86	19.80	
		125.88	9.40	32.72	2.02	
		0.00	0.00	0.00	-5.00	
3		0.00	-5.00	0.00	-10.00	Sandstone bedrock
		183.30	-10.00	183.30	-5.00	

Surcharge

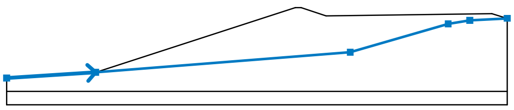
No.	Type	Type of action	Location	Origin	Length	Width	Slope	Magnitude		
			z [m]	x [m]	l [m]	b [m]	α [°]	q, q_1, f, F, x	q_2, z	unit
1	strip	permanent	on terrain	x = 117.00	l = 60.00		0.00	100.00		kN/m2

Surcharges

No.	Name
1	Working loads

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		0.00	-0.14	32.63	1.97	125.80	9.40
		161.68	19.84	169.58	21.11	183.30	21.84

Tensile crack

Tensile crack not input.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Construction stage 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	74.57	[m]	Angles :	α_1 =	-13.55	[°]
	z =	101.93	[m]		α_2 =	34.84	[°]
Radius :	R =	96.30	[m]				
Slip surface after grid search.							

Total weight of soil above the slip surface: 13654.09 kN/m

Slope stability verification (Bishop)

Combination 1

Sum of active forces : F_a = 4337.57 kN/m

Sum of passive forces : F_p = 6073.29 kN/m

Sliding moment : M_a = 413370.10 kNm/m

Resisting moment : M_p = 578784.18 kNm/m

Utilization : 71.4 %

Slope stability ACCEPTABLE

Combination 2

Sum of active forces : F_a = 3176.66 kN/m

Sum of passive forces : F_p = 4356.83 kN/m

Sliding moment : M_a = 305912.04 kNm/m
Resisting moment : M_p = 419562.80 kNm/m
Utilization : 72.9 %

Slope stability ACCEPTABLE

Name : Analysis	**Stage - analysis : 1 - 1**